



Research report

Spatial patterns and cell surface clusters in perineuronal nets



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ABSTRACT

Perineuronal nets (PNN) ensheath GABAergic and glutamatergic synapses on neuronal cell surface in the central nervous system (CNS), have neuroprotective effect in animal models of Alzheimer disease and regulate synaptic plasticity during development and regeneration. Crucial insights were obtained recently concerning molecular composition and physiological importance of PNN but the microstructure of the network remains largely unstudied. Here we used histochemistry, fluorescent microscopy and quantitative image analysis to study the PNN structure in adult mouse and rat neurons from layers IV and VI of the somatosensory cortex. Vast majority of meshes have quadrangle, pentagon or hexagon shape with mean mesh area of $1.29 \mu\text{m}^2$ in mouse and $1.44 \mu\text{m}^2$ in rat neurons. We demonstrate two distinct patterns of chondroitin sulfate distribution within a single mesh – with uniform (nonpolar) and node-enriched (polar) distribution of the *Wisteria floribunda* agglutinin-positive signal. Vertices of the node-enriched pattern match better with local maxima of chondroitin sulfate density as compared to the uniform pattern. PNN is organized into clusters of meshes with distinct morphologies on the neuronal cell surface. Our findings suggest the role for the PNN microstructure in the synaptic transduction and plasticity.

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1. Introduction

Perineuronal nets (PNN) are formed on neuronal surface during early postnatal development as an important functional element of mature synaptic circuits (Medini and Pizzorusso, 2008; Dityatev et al., 2010; Kwok et al., 2012; Fawcett, 2015; Miyata and Kitagawa, 2015). PNN are expressed in the brain cortex, hippocampus, cerebellum, spinal cord and other parts of the CNS. The role of PNN in maturation of the synaptic circuitry of parvalbumin-positive interneurons in somatosensory and visual cortex has been studied in

Abbreviations: PNN, perineuronal nets; CNS, central nervous system; CSPG, chondroitin sulfate proteoglycans; AMPA receptor, α -amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptor; WFA, *Wisteria floribunda* agglutinin; GalNAc, N-acetyl-galactosamine; CS, chondroitin sulfate; PSD95, postsynaptic density protein 95; ECM, extracellular matrix; 2D, two-dimensional; 3D, 3-dimensional; RMSD, root mean square deviation; BDNF, brain-derived neurotrophic factor; NT-3, neurotrophin-3; FGF, fibroblast growth factors; VEGF, vascular endothelial growth factor; GDNF, glial cell-derived neurotrophic factor; PTPsigma, receptor-type tyrosine-protein phosphatase S; Sema3A, Semaphorin-3A

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